A scanning electron microscopic study of debris and smear layer remaining following use of GT rotary instruments

G. Gambarini[1] & J. Laszkiewicz[2]

[1]Department of Periodontics-Endodontics, University of Rome, 'La Sapienza', Rome, Italy, and [2]Department of Conservative Dentistry, Institute of Dentistry, Medical University, Lodz, Poland

Abstract

Gambarini G, Laszkiewicz J. A scanning electron microscopic study of debris and smear layer remaining following use of GT rotary instruments. *International Endodontic Journal*, **35**, 422–427, 2002.

Aim The aim of the present study was to assess debris and smear layer remaining following canal preparation with GT rotary instruments.

Methodology Sixteen freshly extracted single-rooted premolar teeth were instrumented with GT™ rotary instruments using a crown-down preparation technique. All specimens were flushed with 2 mL of 5% NaOCl between each rotary instrument. At the end of instrumentation the following final irrigation sequence was repeated two times: 2 mL of EDTA + Cetrimide for 1 min (Largal Ultra, Septodont, France) and 2 mL of 5% NaOCl for 5 min. A final flush with saline solution was made to halt any chemical activity. Two other uninstrumented teeth that were not irrigated served as controls. All teeth were split longitudinally and prepared for SEM evaluation. The presence of debris and smear layer was evaluated from photomicrographs at ×200 and ×1000 magnification taken in the apical, middle and coronal thirds of the canals. Blind evaluation was performed by two trained observers and scores were compiled separately. A five category scoring system for debris and smear layer was used. Values obtained were tabulated and statistical analysis was carried out using a parametric chi-squared test.

Results Statistical analysis showed that there was no significant difference between the three regions of the root canals ($P > 0.05$) for debris. Comparison of the removal of the smear layer between the three regions showed that there was a statistically significant difference between all parts, especially between the coronal and apical thirds ($P < 0.001$). Overall, the coronal sections were cleaner than the middle and apical sections. The uninstrumented canals showed walls completely covered with tissue, confirming that specimen preparation alone did not remove tissue.

Conclusions Under the conditions of the present study GT™ rotary instruments removed debris effectively, but left root canal walls covered with smear layer, particularly in the apical third.

Keywords: canal debridement, rotary files, scanning electron microscopy.

Received 2 October 2000; accepted 5 June 2001

Introduction

Although thorough cleaning and shaping of the root canal system are considered as key requirements for success in root canal treatment, numerous investigations have demonstrated the limitation of manual and automated root canal instrumentation regarding the overall quality of preparation (Weine *et al.* 1976, Lehman & Gerstein 1982, Turek & Langeland 1982, Bolanos *et al.* 1988, Hülsmann & Stryga 1993, Hülsmann *et al.* 1997, Bertrand *et al.* 1999). These problems have resulted in a wide search for innovative materials, instruments, and techniques to obtain a clean, disinfected, debris-free canal for obturation (Yang *et al.* 1996).

Correspondence: Joanna Laszkiewicz, Department of Conservative Dentistry, Institute of Dentistry, Medical University, Pomorska 251, 92–213 Lodz, Poland (fax: +0048 42 678 93 68).

Since most hand preparation techniques are time consuming, technically demanding and may lead to iatrogenic errors (ledging, zipping, canal transportation and apical blockage), attention has been directed toward nickel–titanium rotary instruments. Numerous studies have reported they could efficiently create a smooth, predetermined funnel-form shape, with minimal risk of ledging and transporting the canals (Esposito & Cunningham 1995, Glosson *et al.* 1995, Short *et al.* 1997, Thompson & Dummer 1997b). Shaping procedures can be completed more easily, quickly and predictably, but effective cleansing of the entire root canal system using Ni–Ti rotary instruments has not yet been demonstrated (Siqueira *et al.* 1997).

The purpose of the present study was to investigate the efficiency of GT rotary instruments in removing debris and smear layer from root canal walls.

Materials and methods

Sixteen freshly extracted single-rooted mandibular premolar teeth with straight canals (radius of curvature less than 5°) and closed apices were used. None of the teeth had received restorative or endodontic therapy. Following extraction, the teeth were stored at 4°C in isotonic saline solution to avoid any effect that fixative might have on the dissolution of organic tissue.

Conventional endodontic access cavities were prepared (Endo Access Bur, Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed handpiece. If initial instrumentation to the apical foramen could not be performed with a size 10 K-file the teeth were excluded from the study. To determine working length a size 10 K-file was inserted until it reached the apical foramen and one-half millimetre subtracted from this length. A small amount of wax was placed on the tip of each root to prevent irrigating solutions from passing through the apical foramen.

Canal instrumentation

All canals were prepared using nickel–titanium rotary instruments (GT™ Rotary Files, Dentsply Maillefer, Ballaigues, Switzerland) and a crown-down canal preparation technique. Preliminary coronal enlargement was achieved with the sequential use of GT instruments with .12, .10, .08, and .06 taper. Instruments were advanced slowly into the canal exerting only a light force (passive instrumentation). Apical stop preparation was completed with .04 tapered GT™ rotary instruments sizes 20–35 to ensure adequate apical enlargement. Instruments were used in a controlled, slow speed, high torque motor at a speed of 250 r.p.m. All teeth were prepared by the same operator.

Root canals were irrigated with 2 mL of 5% NaOCl (Niclor, Ogna, Italy) between each instrument and kept flooded with irrigant during the instrumentation phase. The irrigant was delivered with an endodontic syringe with a 27-gauge blunt needle that had been placed down the canal until slight resistance was felt. At the end of instrumentation, the following final irrigation sequence was repeated two times: 2 mL of EDTA + Cetrimide for 1 min (Largal Ultra, Septodont, France) and 2 mL of 5% NaOCl for 5 min. A final physiological solution rinse was then used to neutralize the action of the irrigating agents (Gambarini 1999). Canals were dried with sterile standardized paper points.

Two other uninstrumented and unirrigated teeth served as a control. The teeth were stored in isotonic saline solution until they were prepared for SEM examination.

SEM examination

The crowns of the teeth were removed at the cemento–enamel junction. To facilitate fracture into two halves for SEM examination, all roots were grooved longitudinally on the external surfaces with a diamond disk, avoiding penetration of the root canals. The teeth were then carefully split with a hammer and chisel, and prepared for scanning electron microscopic evaluation. The two halves were dehydrated in a graded series of ethanol solutions, critical point dried, attached to coded stubs, coated with gold, and viewed with a scanning electron microscope (JSM-JEOL Co., Ltd., Tokyo, Japan). Photomicrographs at ×200 (for debris score) and ×1000 (for the smear layer) were taken in the apical, middle and coronal thirds of the canals.

Separate blind evaluations were undertaken by two trained observers for debris and smear layer with a five score index for each, using reference photographs. Three microscopic fields at ×200 and six microscopic fields at ×1000 were randomly assessed in each third of each half of the root. Each field was graded from 1 to 5 according to the scoring system and the mean value was calculated for each region of each half of the root. The rating system used was proposed by Hülsmann *et al.* (1997) and criteria for the scoring were the following:

Score of the debris (Fig. 1 a–e):

Score 1: Clean root canal wall, only few small debris particles.

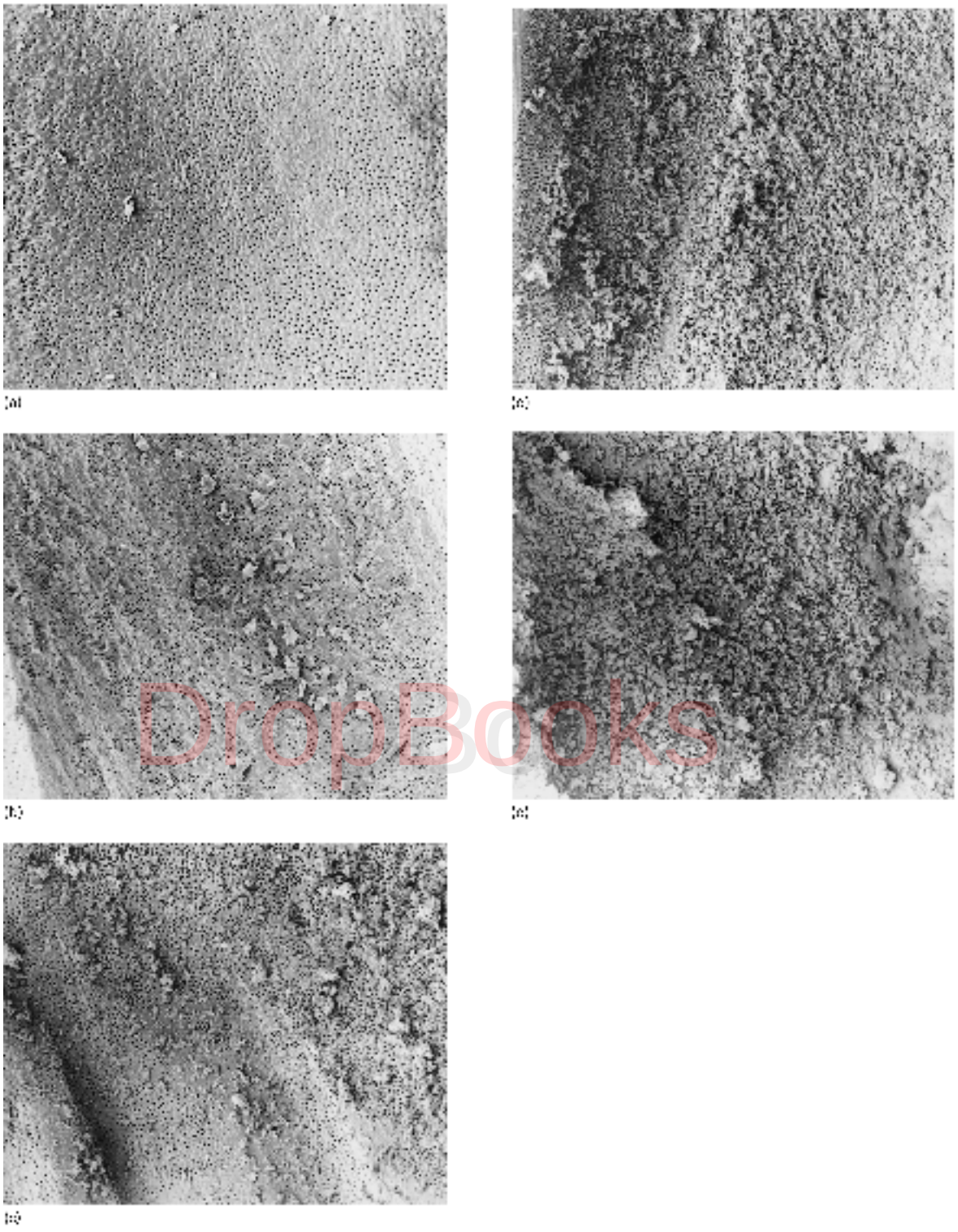

Figure 1 Standardized score of the the debris for specimen evaluation: (a) score 1; (b) score 2; (c) score 3; (d) score 4; (e) score 5. Original magnification ×200.

Score 2: Few small agglomerations of debris.
Score 3: Many agglomerations of debris covering less than 50% of the root canal wall.
Score 4: More than 50% of the root canal wall covered by debris.
Score 5: Complete or nearly complete root canal wall covered by debris.

Score of the smear layer (Fig. 2 a–e):

Score 1: No smear layer, dentinal tubules open.
Score 2: Small amount of smear layer, some dentinal tubules open.
Score 3: Homogenous smear layer covering the root canal wall, only few dentinal tubules open.
Score 4: Complete root canal wall covered by a homogenous smear layer, no open dentinal tubules.
Score 5: Heavy, non-homogenous smear layer covering the complete root canal wall.
Data were recorded and analysed statistically. Because of the ordinal nature of the scores, the parametric chi-squared test was used.

Results

Mean canal preparation time was 7.20 min (SD 0.5).

Mean scores for debris removal in the coronal, middle and apical thirds were 1.06, 1.38 and 2.25, respectively. Although the best results were observed in the coronal sections, statistical analysis showed that there was no significant difference ($P > 0.05$) in debris between the three regions of the root canals.

Mean scores for smear layer removal in the coronal, middle and apical thirds were 1.50, 2.00 and 3.38, respectively. Comparison of the removal of smear layer between the three regions showed that there was a statistically significant difference ($P < 0.001$) between all parts, especially between the coronal and apical thirds (Table 1).

The uninstrumented canals showed walls completely covered with tissue, confirming that specimen preparation alone did not remove tissue.

Table 1 Comparison of the removal of the smear layer between the three regions of the canal

Comparison of parts	Value of chi-squared test	*P*
Coronal – middle	8.0	$P < 0.01$
Coronal – apical	19.2	$P < 0.001$
Middle – apical	4.571	$P < 0.05$

Discussion

The ability to clean effectively the endodontic space is dependent on both instrumentation and irrigation. Endodontic instruments may, in themselves, vary in their debris removal efficacy and in their smear layer production, due to their specific flute design (Bertrand *et al.* 1999). Irrigation plays a key role in successful debridement and disinfection. Sodium hypochlorite is an irrigant solution widely used in root canal treatment because of its bactericidal properties and ability to dissolve organic tissue, however, it is not effective in removing the inorganic smear layer. Therefore, a combination of NaOCl and EDTA has been reported to be suitable for removing both the organic tissues and inorganic smear layer (Baumgartner & Mader 1987).

More recently, it has been shown (Gambarini 1999) that cleaning can be significantly improved once the shaping procedure has been completed (the 'shaping and cleaning' concept). At the end of instrumentation, root canal diameters have been adequately enlarged to a funnel-form shape that provides easier and superior penetration of the irrigants in the apical portions. At this stage, no further instrumentation is required and, consequently no more smear layer is produced. This allows the irrigating solutions, which are left undisturbed for an adequate period of time, to efficiently remove the remaining debris.

The results of the present study showed that GT™ rotary instrumentation followed by a specific final irrigation sequence could produce good canal cleanliness. In most cases, canal surfaces were smooth and free of pulpal remnants.

The new file design seemed to be effective in debris removal. However, it is important to note that the GT rotary instrumentation sequence used in our study is the one recommended by the manufacturer, which consisted of eight rotary instruments. No Accessory GT rotary instruments were used. It means that after initial use of the four standard GT rotary instruments, apical preparation was completed with .04 tapered GT rotary instruments sizes 20–35. Those instruments are essentially ProFile .04 instruments. Cleaning in the apical third is therefore related to the combined action of two different rotary instruments (GT and ProFile) and the large apical stop produced.

Use of the rotary instrumentation resulted in a substantial amount of smear layer. This smear layer consists of dentine particles and pulp tissue closely compacted against the root canal wall and extending into the dentinal tubules (McComb & Smith 1975, Mader *et al.* 1984,

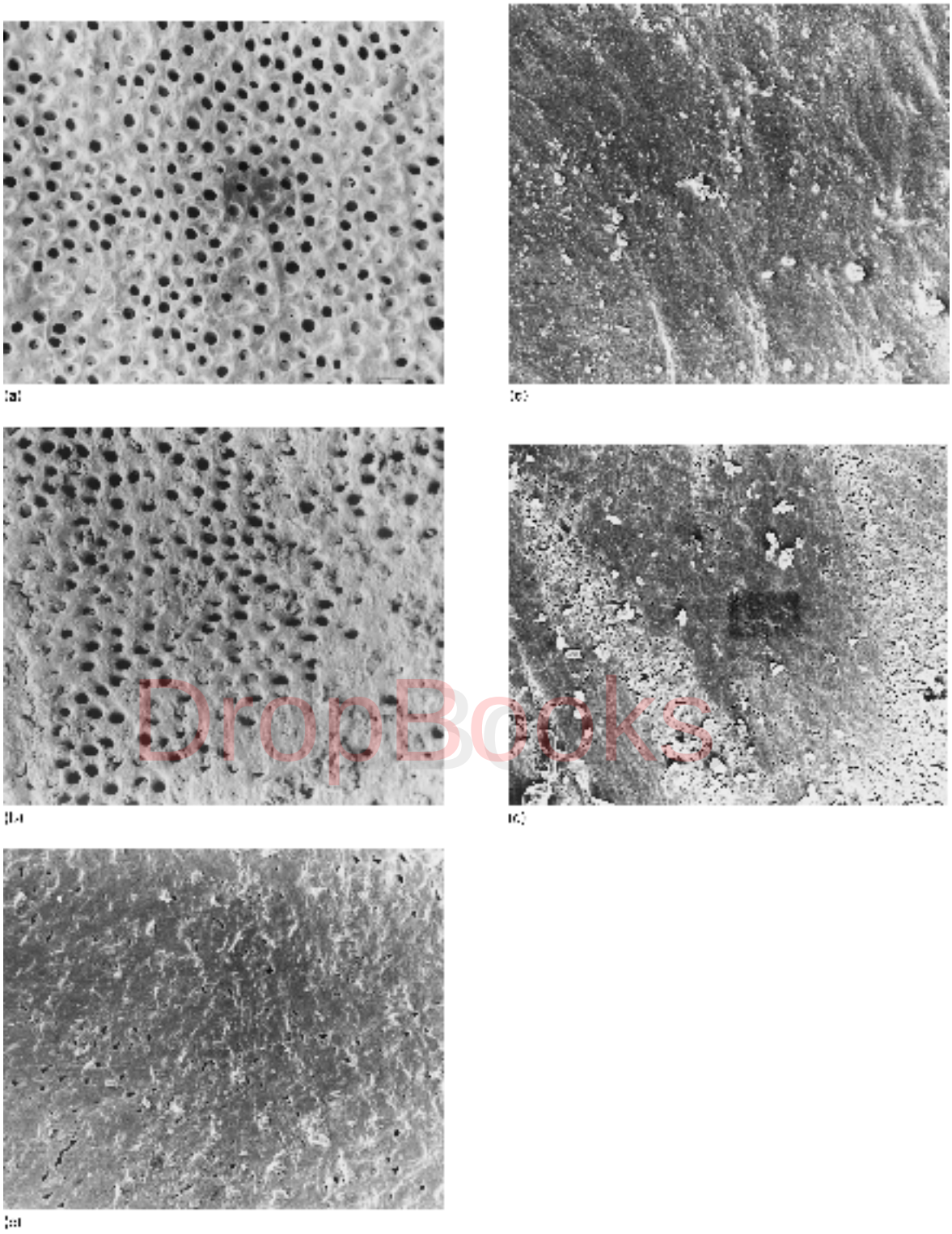

Figure 2 Standardized score of the smear layer for specimen evaluation: (a) score 1; (b) score 2; (c) score 3; (d) score 4; (e) score 5. Original magnification ×1000.

Bechelli *et al*. 1999). The smear layer produced by instrumentation should be removed, because it could contain bacteria and increase leakage of the canal filling (Yamada *et al*. 1983, Aktener *et al*. 1989). Following this hypothesis, additional irrigation with antibacterial solutions or chelating agents has been recommended by many authors to remove debris as well as the smear layer, however, this did not produce the expected smear-free surfaces in the apical third of the canal.

Conclusions

It is concluded that under the conditions of this study GT rotary instruments removed debris effectively in all sections of the canal, but left root canal walls covered with smear layer, particularly in the apical part.

References

Aktener BO, Cengiz T, Pişkin B (1989) The penetration of smear material into dentinal tubules during instrumentation with surface active reagents: a scanning electron microscopic study. *Journal of Endodontics* **15**, 588–90.

Baumgartner JC, Mader CL (1987) A scanning electron microscopic evaluation of four root canal irrigation regimes. *Journal of Endodontics* **13**, 147–57.

Bechelli C, Zecchi Orlandini S, Colafranceschi M (1999) Scanning electron microscope study on the efficacy of root canal wall debridement of hand versus Lightspeed instumentation. *International Endodontic Journal* **32**, 484–93.

Bertrand MF, Pizzardini P, Muller M, Médioni E, Rocca JP (1999) The removal of the smear layer using the Quantec system. A study using scanning electron microscope. *International Endodontic Journal* **32**, 217–24.

Bolanos OR, Sinai IH, Gonsky MR, Srinivasan R (1988) A comparison of engine and air-driven instrumentation methods with hand instrumentation. *Journal of Endodontics* **8**, 392–6.

Esposito PT, Cunningham CJ (1995) A comparison of canal preparation with Nickel–Titanium and Stainless Steel instruments. *Journal of Endodontics* **21**, 173–6.

Gambarini G (1999) Shaping and cleaning the root canal system: A scanning electron microscopic evaluation of a new instrumentation and irrigation technique. *Journal of Endodontics* **25**, 800–3.

Glosson CR, Haller RH, Dove SB, del Rio CE (1995) A comparison of root canal preparation using Ni–Ti hand, Ni–Ti engine driven, and K-Flex endodontic instruments. *Journal of Endodontics* **21**, 146–51.

Hülsmann M, Rümmelin C, Schäfers F (1997) Root canal cleanliness after preparation with different endodontic handpieces and hand instruments. A comparative SEM investigation. *Journal of Endodontics* **23**, 301–6.

Hülsmann M, Stryga F (1993) Comparison of root canal preparation using different automated devices and hand instrumentation. *Journal of Endodontics* **19**, 141–5.

Lehman JW, Gerstein H (1982) An evaluation of a new mechanized endodontic device: the Endolift. *Oral Surgery, Oral Medicine and Oral Pathology* **53**, 417–24.

Mader CL, Baumgartner JC, Peters DD (1984) Scanning electron microscopic investigation of the smeared layer on root canal walls. *Journal of Endodontics* **10**, 477–84.

McComb D, Smith DC (1975) A preliminary scanning electron microscope study of root canals after endodontic procedures. *Journal of Endodontics* **1**, 238–42.

Short JA, Morgan LA, Baumgartner JC (1997) A comparison of canal centering ability of four instrumentation techniques. *Journal of Endodontics* **23**, 503–7.

Siqueira JF Jr, Araújo PFG, Garcia PF, Fraga RC, Sabóia Dantas CJ (1997) Histological evaluation of the effectiveness of five instrumentation techniques for cleaning the apical third of root canals. *Journal of Endodontics* **23**, 499–502.

Thompson SA, Dummer PMH (1997b) Shaping ability of ProFile.04 Taper Series 29 rotary nickel–titanium instruments in simulated root canals. Part 2. *International Endodontic Journal* **30**, 8–15.

Turek T, Langeland K (1982) A light microscopic study of efficacy of the telescopic and Giromatic preparation of root canals. *Journal of Endodontics* **8**, 437–43.

Weine FS, Kelly RF, Bray KE (1976) Effect of preparation with endodontic handpieces on original canal shape. *Journal of Endodontics* **2**, 298–303.

Yamada RS, Armas A, Goldman M, Lin PS (1983) A scanning electron microscopic comparison of a high volume final flush with several irrigating solutions: part 3. *Journal of Endodontics* **9**, 137–42.

Yang SF, Rivera EM, Walton RE, Baumgartner KR (1996) Canal debridement: effectiveness of sodium hypochlorite and calcium hydroxide as medicaments. *Journal of Endodontics* **22**, 521–5.